If we except the 15th, there were ten years when not over 0.04 inch of rain fell on any one day.

If we compare this period with the period September 26 to October 6, which latter has but seven years with less than 0.04 inch of rainfall on any one day, we must admit that there is *no* "unfailing regularity" and that the "result of equinoctial disturbances" is *not* apparent.

In other words the annual changes of season are in general owing to the movement of the sun north and south, but do not have any close connection with the date of solstice or equinox.—*H. H. K.*

THE NOVEMBER METEORS.

While meteorology in its broadest sense includes all phenomena occurring in the earth's atmosphere, the study of meteors or shooting stars pertains more particularly to the science of astronomy. No special effort was therefore made by the Weather Bureau to obtain observations of the expected November shower of Leonids, further than that existing instructions require that all meteors observed shall be noted in the daily journal. Very interesting special reports were made, however, by the observers at Phoenix, Ariz., and Havre, Mont., and these, together with the following extracts from daily journals at a few other stations, show to what extent the Leonids were seen by Weather Bureau observers. Doubtless, many more reports would have been received but for the fact that no instructions were issued, and that the principal display appears to have occurred between 5 a. m. and 8 a. m. of the 15th, just previous to the hour when our morning observers go on duty, and about the time day was breaking in the eastern part of the United States.

These reports serve to illustrate the importance of a knowledge of other branches of science besides meteorology, if our observers are to record accurately all that comes under their notice. The present course of study outlined by the Chief of Bureau for candidates for promotion provides for just this kind of general information.

LEONIDS AT PHOENIX, ARIZ.

By D. S. LANDIS, Observer, Weather Bureau, dated November 20, 1901.

The Leonids observed at Phoenix, Ariz., showed to a fine advantage on the morning of the 15th, owing to a perfectly clear sky. The greatest display occurred about 5 a. m., local time. The showers were not constant, but came at intervals of about two minutes. A bevy would streak the sky for a few seconds, then the number would dwindle away to a straggling few here and there until another shower would come on. Within ten minutes four profuse and distinct showers were noted.

Twenty Leonids were counted within one minute flying over a space checked off by a house top. The angle of descent seemed to be about forty degrees from the perpendicular. The path of translation was due northwest, except in cases where violent explosion was apparent, causing deflection. In one instance an explosion was noticed wherein the main part of the Leonid was deflected to the southwest, and two zig zag lances of yellow flame darted off to the northeast.

The prevailing color was white. Some were tinged with yellow, a few were bluish, and others had tintings of red, both on the head and the edges of the wake of light. Most of the bodies showed a brilliant white center with purplish borders. One very large one resembled a six-inch globe of cankerous fire with spicules of red and yellow radiating from all points on the surface.

The path of light behind each body spread out into a feathery fan shape, and explosions were evident in the train of light, for the larger points would fly violently into a powdery haze, scintillate in a sort of luminous effervescence, and go out.

The first appearance of a Leonid coming toward you from the southeast showed a reddish point of light which quickly merged into a yellow hue, mixed with blue, then flared into an incandescent splendor. As the Leonid approached, the point increased rapidly in size, sometimes to apparently six inches in diameter, then tapered down to powdery sparks which invariably showed a violet caste before disappearing.

The sizes varied from mere beads of flaring white, with thin iris colored threads behind, to globes half a foot in diameter, with explosive trains of variegated lights hundreds of yards in length.

The life of some of the larger Leonids was fully five seconds from the time of the first point of light to the fading away of the luminous dust into darkness.

It would have been impossible to have counted the number, for they rained down from all points of the heavens at intervals of about two minutes apart, and the descent continued until the morning light obscured them.

LEONIDS AT HAVRE, MONT.

By C. W LINE, Observer Weather Bureau, dated November 15, 1901.

A beautiful display of Leonids or shooting stars was observed at this station this morning. When I stepped out of the door at 7:30 a. m. (seventy-fifth meridian time), I looked up at the constellation Leo and saw four meteors in less than that many seconds. After I had filed my morning report I met the night policeman, who was waiting to tell me about the unusual number of shooting stars he had seen during the preceding hour. I explained to him what they were and showed him the point from which they radiated. We then watched these meteors for over half an hour and saw at least a hundred of them. Some were of great brilliancy, and some were actually seen to radiate directly from the constellation Leo, and all seemed to emerge from within the sickle in that constellation. At intervals they came into the earth's atmosphere at the rate of one a second for at least six seconds. As long as a star could be seen in this constellation these shooting stars appeared and continued until the great circle of illumination shut off all further view of them.

Abstracts from Daily Journals of November 15, 1901.

(*a*) Forth Worth, Tex., John Shultz, Observer: Although frequent observations were made during the night only a few meteors were seen before 5:10 a. m. From that time until 5:20, 76 were counted; from 5:20 to 5:50, 60; and from 5:50 to 6:30 only 6 were observed. They appeared at irregular intervals, and as there were frequently from 5 to 10 or more visible at a time, it is probable that a great many were not counted. Many of them were remarkably brilliant and beautifully colored. With few exceptions, they all came from a portion of the sky embraced within a circle of about 15° in diameter, and the center of which was about 4° above the star Regulus. The short paths of the meteors was a notable feature of the display; only a few appeared to go overhead toward the west-northwest, the remainder descending in nearly vertical paths, deflected slightly toward the north or south. All of them showed evidence of rapid disintegration; the brightest ones left continuous trails, with numerous fragments thrown off laterally, but the trails of the fainter ones had a broken or chain-like appearance.

(*b*) Independence, Cal, John McLean, Observer: Meteoric shower reported in the northern heavens by Mr. Anton immediately after the observer came down from roof platform at about 7:47 a. m. About twenty-five meteors were seen moving in different directions.

(*c*) Amarillo, Tex., James F. Atherton, Observer: Moderate shower of Leonids observed at early dawn.

(*d*) Cairo, Ill., Patrick H. Smyth, Observer: Meteor observed at 7.09 a. m. First seen at an altitude of about 30°, azimuth about 335°; course easterly or nearly so. Meteor appeared about the size of the morning star, the only star visible at the time.—*H. H. K.*

ICE CAVES AND FREEZING WELLS.

In the National Geographic Magazine for December, 1901, Vol. XII, p. 433, Mr. W J McGee writes as follows on the above subject:

It is greatly to be regretted that recent writers on ice caves and frozen wells have not extended observation to the "blowing caves," "breathing wells," and "whistling wells" found in various parts of this and other countries, and sporadically recorded in ephmeral literature; for the physical laws exemplified in these are alike, and presumptively connected with those revealed in glacières and ice wells.

* * * * * * *

Now it is evident that when the barometer is high in a region of caves or breathing wells, the subterranean chambers or pervious beds will gradually fill with the slightly compressed air, and that the process of filling will be accompanied by inspiration, or in-blowing through the open mouth; it is equally evident that with the subsequent fall of the barometer the imprisoned air will expand and force itself outward through the mouth of the cavern until the pressure within and without is brought into balance. Furthermore it is evident that the air expanding in the throat of the orifice will abstract heat from surrounding substances, precisely as it does in the expansion chamber of an atmospheric ice machine, at a rate and to an amount varying with the

pressure difference; and hence that (provided other conditions be favorable) the moisture on adjacent surfaces may be congealed. In short, under favorable circumstances, the breathing well or blowing cave may become a natural ice machine, clumsy and inefficient, indeed, yet possibly making up in magnitude for its simplicity and the slightness of the pressure differences within its reach. Of course it would seem at first sight that in each passage from low pressure to high and back again, as in the long run, the effects of the natural mechanism would balance, i. e., that the heat given off in inspiration would equal the chill of expiration, so that no refrigeration could ensue; yet when the seasonal ranges of barometer and thermometer are considered, it would seem clear that the heating would tend to culminate in autumn and the chill in spring, in such wise as to sustain the widespread popular opinion on the subject, i. e., that the period of ice melting runs into winter and that of ice forming into late spring and summer.

This is evidently an interesting subject for investigation on the part of the numerous voluntary observers of the Weather Bureau. As Mr. McGee points out, there is a lack of definite information in regard to many features of ice caves. From the fact that ice is occasionally found in July where it is not found in January, the erroneous conclusion has sometimes been reached that there are caves in which ice forms during the summer and melts during the winter. It also appears that measurements of currents flowing into or out of caves are very much to be desired. My own observations[1] indicate that there can be only a slight movement of the air into or out of an ice cave during the summer. A rapid circulation of the air would soon melt the ice, and it is because a circulation can not be maintained that the ice is preserved.

Observations of the temperature of the air in ice caves each month, or, better still, each week, together with measurements to determine whether the ice deposit is increasing or diminishing, would throw much light on the process of ice formation. At the same time it would be a simpler matter to ascertain by means of a light thread held in the hand, or even by observing the movement of the fog from the breath, whether there is any perceptible flow of air into or out of the cave. This latter observation should be made in the passageway leading to the bottom of the cave, where the ice usually forms, as well as near the ice itself. There is danger of mistaking the movement of the air past the mouth of the cave for a movement out of it, and observations at this point should therefore be taken with great caution.

It would also be interesting to notice whether there is any marked increase in the circulation of the air in caves in winter over that in summer.

Already two of our voluntary observers have sent us communications on the subject of ice caves. Mr. A. D. Elmer, Northfield, Mass., writes that there is a cave in the Northfield Mountains in which ice is often found as late as August. He also refers to a very cold stream of water of considerable size in Hilsdale, N. H., over which a thin fog hangs in summer. We should very much like data in regard to the temperature of this stream, and also with respect to the prevalence of fog upon it at different seasons of the year.

Mr. Galloway C. Morris, Caldwell, Warren Co., N. Y., writes of a cave in his vicinity from which ice is often obtained in August. He proposes to make systematic observations in this cave during the coming year.

We can hardly consider an ice cave to be even a crude form of "atmospheric ice machine," as suggested by Mr. McGee. The expansion is not sudden enough nor the range of pressure great enough to produce any appreciable cooling. We must distinguish between the sudden expansion that takes place in the chamber of an air pump and the slow processes of nature.

But let us assume that the present changes continually taking place in nature are accompanied by corresponding changes in temperature at the adiabatic rate. Leaving out of the question the pressure variations due to cyclonic and anticyclonic movements, which, as Mr. McGee has said, must balance each other in the course of the year, we have left differences in the normal pressure from winter to summer, which at sea level amount to only one or two tenths of an inch of mercury. From Professor Bigelow's tables[2] we find that the adiabatic cooling due to a diminution of pressure by 1 inch is only about 5° F., so that the cooling due to expansion from winter to summer mean pressure could hardly amount to more than 1° F. in that part of the cave where the ice is usually found.

Mr. McGee suggests another way in which cooling might be effected. He shows that any marked diminution of the external air pressure must cause a decided flow of air out of the cave; and this outflowing air will expand, especially as it passes through the cave's throat, thereby reducing the temperature at that point. But to make this method effective, it is necessary that the cave be very large and its throat very small; and the ice will be formed, not necessarily at the bottom of the cave, but on the walls at the narrowest part of the outlet, or about the cave's throat. Are there caves in which the ice is formed in this way?—*H. H. K.*

[1] Monthly Weather Review, August, 1901, Vol. XXIX, p. 366.

THE TEMPERATURE OF WATER IN WELLS.

Mr. R. J. Redding, Voluntary Observer, and Director of the Georgia Experiment Station, has sent us the following communication:

I remember seeing it stated in some publication, many years ago, that there is a close correspondence between the mean annual temperature of the water of ordinary wells and the mean annual temperature of the air above the same location. In connection with the statement it was suggested that a traveler, if supplied with a good thermometer, might approximately ascertain the mean annual temperature of the air of any region by simply finding by actual test the temperature of the wells. I have looked in vain for any amplification of the statement in some encyclopedia or other repository of popular information. In a desultory way I have verified the statement quite a number of times but have kept no record of observations, and can only write from memory: In Ocala, Fla., I found the temperature of the well water (February) to average about 72° F.; in Americus, Ga., 66°; in Ellaville, Ga., 66°; in Macon, Ga., 65°; Experiment, Ga., 62°; Atlanta, Ga., 60°; Dahlonega, Ga., 56°; Minneapolis, Minn., 46°. These are all the observations I can recall, but I have made others. On referring to a standard isothermal chart I found a very close correspondence between the temperature above noted and the mean annual temperatures of the air of the same locality. When I have had opportunity to note temperatures of the water of a given well at all seasons of the year I have observed a variation of as much as 2° between the maximum and the minimum, where the well was not deeper than 25 to 30 feet. This range decreases as the depth increases until, according to my limited observations, when the depth of 50 to 60 feet is reached there is no perceptible variation, the temperature of the water remaining uniform the year round. In shallow wells, say 25 to 30 feet, the water was found to be colder by one or two degrees in June than in December, which suggests that it requires about six months for the extreme temperature of the air above to become manifest at that depth. I have thought that this fact explains and justifies the claim often made by well owners, that their well water is colder in midsummer than in midwinter.

The temperature of water in wells must evidently be intimately connected with the temperature of the ground at different depths. Unfortunately, comparatively little attention has been given to this subject in the United States, although it has been quite thoroughly studied in Europe. Perhaps the best series of observations are those that were made at Munich, Bavaria[1] from 1861–1885, and from which a diagram was constructed showing the mean temperature of the ground at different depths for each month of the year. This diagram has

[2] Report of the Chief of the Weather Bureau, 1898–99, Vol. II, pp. 550–553.

[1] Die Bodentemperature an der K. Sternwarte bei München. Von Dr. K. Singer. Anhang. Deutsches Meteorologisches Jahrbuch, 1889. Band XI.